# ATTENUATION CONTROL FOR TUNERS

## Technical Field of the Invention

The present invention relates to the control of

5 the amount of attenuation within a tuner to prevent

overload of the tuner's mixer or mixers.


## Background of the Invention

A tuner is provided in receivers such as radios

10 and televisions to tune to a channel selected by a user.

The tuner typically comprises a mixer that mixes the

received RF signal with a local oscillator signal having

a frequency corresponding to a selected channel. The

output of the mixer is a predetermined intermediate

15 frequency signal. In order to prevent the mixer from

being overloaded by the received RF signal, an

attenuator, such as a PIN diode attenuator, is provided

between the RF input and the mixer. The attenuator is

intended to ensure that the signal in the tuner is not so

20 large so as to overload the mixer.

Figure 1 shows an upconverting section 10 of a

double conversion tuner without band limiting that

provides an example of attenuation control in accordance

with the prior art. The upconverting section 10 has an

25 RF input 12 that receives an RF signal such as from an

antenna. The RF signal is supplied to an attenuator 14

(such as a PIN diode attenuator) that is provided to attenuate the RF signal, and the RF signal at the output of the attenuator 14 is amplified by an RF amplifier 16. The RF signal at the output of the RF amplifier 16 is

5    supplied through a directional coupler 18 to a broadband filter 20 that is arranged to filter out signal components having frequencies outside of a selected range.  For example, for television applications, the broadband filter 20 filters out signal components having

10   frequencies outside of the frequency range of 50-800 MHz. The RF signal at the output of the broadband filter 20 is provided to the RF input of a mixer 22 which also receives a local oscillator signal LO from a local oscillator.  The mixer 22 mixes the RF signal on its RF

15   input with the local oscillator signal to produce an output IF signal.

         The directional coupler 18 provides coupling to the incident voltage on the line between the RF amplifier 16 and the broadband filter 20 to an amplifier 24, and

20   this amplified voltage is provided to a detector 26.  In this way, the detector input level is not affected by input impedance variations of the broadband filter 20 which otherwise would cause attenuation variations.  The detected signal at the output of the detector 26 is used

to control the attenuator 14 such that, as the incident

voltage at the output of the RF amplifier 16 becomes too

large, the RF signal is attenuated to prevent overloading

of the mixer 22.

5        The problem with the upconverting section 10 is

the cost of the directional coupler 18 and the

technological incompatibility of the directional coupler

18 with the eventual tuner integration process.


10  Summary of the Invention

        In accordance with one aspect of the present

invention, a tuner comprises an RF input, a signal level

controller, a feedback amplifier, a mixer, and a

feedback.  The signal level controller is coupled to

15  attenuate a signal from the RF input.  The feedback

amplifier is coupled to provide first and second outputs

representing power of the attenuated signal.  The mixer

is coupled to mix at least one of the outputs of the

amplifier with a local oscillator signal.  The feedback

20  is coupled to control the attenuation provided by the

signal level controller in response to the power of the

attenuated signal.

        In accordance with another aspect of the

present invention, a tuning method comprises the

following:  attenuating an RF signal received at an RF
input;  mixing the attenuated signal with a local
oscillator signal to produce an intermediate frequency
signal;  developing a signal representing the power of

5    the attenuated signal;  and, controlling the attenuation
of the RF signal in response to the signal representing
the power of the attenuated signal so as to inhibit
overloading of the mixer.


10   Brief Description of the Drawings

These and other features and advantages of the
present invention will become more apparent from a
detailed consideration of the invention when taken in
conjunction with the drawings in which:

15          Figure 1 illustrates a prior art upconverting
section of a double converting tuner without band
limiting;

Figure 2 illustrates an upconverting section of
a double conversion tuner with RF band limiting in

20   accordance with one embodiment of the present invention;

Figure 3 illustrates an RF band limited double
conversion tuner in accordance with another embodiment of
the present invention; and,

Figure 4 illustrates a conventional single

conversion tuner improved in accordance with yet another

embodiment of the present invention.


5   Detailed Description

An upconverting section of a double conversion

tuner 30, as shown in Figure 2, has an RF input 32 for

receiving an RF signal such as from an antenna.  The RF

signal on the RF input 32 is supplied to an attenuator 34

10   (such as a PIN diode attenuator) which is provided to

attenuate the RF signal.  The RF signal at the output of

the attenuator 34 is filtered by a tunable RF filter 36

and is amplified by an RF amplifier 38.  The RF signal at

the output of the RF amplifier 38 is supplied to a

15   broadband filter 40 that is arranged to filter out any

signal components having frequencies outside of a

selected range.  For example, for television

applications, the broadband filter 40 filters out signal

components having frequencies outside of the frequency

20   range of 50-800 MHz.  The RF signal at the output of the

broadband filter 40 is provided to the RF input of a

'mixer 42 which also receives a local oscillator signal LO

from a local oscillator.  The mixer 42 mixes the RF

signal available at the output of the broadband filter 40

with the local oscillator signal LO to produce an output IF signal.

The RF amplifier 38 includes a transistor 44 having a gate 46 coupled to the output of the tunable RF filter 36. The transistor 44 also has electrodes 48 and 50. These electrodes may be drain and source electrodes in the case where the transistor 44 is a field effect transistor as shown in Figure 2. However, the transistor 44 may be any other suitable type of an RF transistor.

The electrode 48, which is the output of the RF amplifier 38, is coupled to the broadband filter 40. The electrode 48 is also coupled through a phase compensated divider 52 to an input 54 of an amplifier 56. The input 54, for example, may be a negative input of the amplifier 56. The phase compensated divider 52 attenuates the voltage at the electrode 48 to a level comparable to the voltage at the electrode 50 and compensates for any phase shift caused by the RF amplifier 38. The phase compensated divider 52 includes a resistor 58, a capacitor 62, and a resistor 64. The resistor 58 and the capacitor 62 are coupled in parallel, and the parallel combination of the resistor 58 and the capacitor 62 couples the electrode 48 through a DC decoupling capacitor 60 to the input 54 of the amplifier 56. The

resistor 64 is coupled on one end to a junction of the
resistor 58 and the DC decoupling capacitor 60 and on the
other end ground.

The electrode 50 of the transistor 44 is
5    coupled through another DC decoupling capacitor 68 to an
input 70 of the amplifier, and is also coupled to ground
through a resistor 72 providing resistive series feedback
and closing the DC circuit of the transistor 44 to
ground.  The input 70, for example, may be a positive
10   input of the amplifier 56.  A resistor 74 and a DC
decoupling capacitor 76 are coupled in series between the
gate 46 and the electrode 48 of the transistor 44 to
provide parallel resistive feedback for the amplifier 38.

The output of the amplifier 56 is coupled to a
15   detector 78, and the output of the detector 78 is coupled
through a resistor 80 to the attenuator 34.  The junction
of the resistor 80 and the attenuator 34 is coupled to
ground through a capacitor 82 introducing thus the
necessary delay into the AGC loop.  The resistor 80,
20   which is in parallel with the attenuator control port
input resistance and output resistance of the detector
78, and the capacitor 82 determine a time constant for
the automatic gain control.

The detected signal at the output of the detector 78 is used to control the attenuator 34 such that the RF signal is attenuated in order to prevent overloading of the mixer 42. The voltage on the

5   electrode 48 is directly the output voltage of the RF amplifier 38, and the voltage on the electrode 50 is proportional to the current in the RF amplifier 38. Therefore, the amplifier 56 receives two signals, a first signal representing the voltage of the attenuated signal

10  (i.e., a properly scaled down voltage from the voltage at the output of the RF amplifier 38), and a second signal representing the current of the attenuated signal. These first and second signals provided by the RF amplifier 38 together closely represent the incident power at the

15  output of the RF amplifier 38. These first and second signals provided by the RF amplifier 38 are combined by the amplifier 56 and are then used to control the attenuator 34.

Variations in the impedance of the broadband

20  filter 40 are compensated because the first and second signals provided by the RF amplifier 38 complement each other as the impedance of the broadband filter 40 varies. For example, as the input impedance Z of the broadband filter 40 increases, the first signal on the electrode 48

increases while the second signal on the electrode 50

decreases, thereby stabilizing sufficiently the control

of the attenuator 34.

A double conversion tuner embodiment 100, as

5 shown in Figure 3, has an RF input 102 for receiving an

RF signal such as from an antenna.  The RF signal is

supplied to an attenuator 104 (such as a PIN diode

attenuator) which is provided to attenuate the RF signal.

The RF signal at the output of the attenuator 104 is

10 filtered by a tunable RF filter 106 and is amplified by

an RF amplifier 108.  The RF signal at the output of the

RF amplifier 108 is supplied to a broadband filter 110

that is arranged to filter out signal components having

frequencies outside of a selected broad frequency range.

15 For example, for television applications, the broadband

filter 110 filters out signal components having

frequencies outside of the frequency range of 50-800 MHz.

The RF signal at the output of the broadband

filter 110 is provided to the RF input of an upconverting

20 first mixer 112 which also receives a local oscillator

signal LO1 from a local oscillator.  The upconverting

first mixer 112 mixes the RF signal from the broadband

filter 110 with the local oscillator signal LO1 to

produce an initial intermediate frequency signal.

The initial intermediate frequency signal from
the upconverting first mixer 112 is supplied to a
wideband filter 114.  The purpose of the wideband filter
114 is mainly to minimize the effect of spurious
5   frequencies generated by the mixing of the two local
oscillator harmonics.  The bandwidth of the wideband
filter 114 has to be somewhat wider than the bandwidth of
the tunable RF filter 106 for the AGC to function
properly.  The AGC frequency response has to be that of
10  the RF filter 110 preceding the first mixer 112.  That
would not be the case if the wideband filter 114 was
narrower than the tunable RF filter 106.

The signal at the output of the wideband filter
114 is amplified by an first IF amplifier 116.  The
15  signal at the output of the first IF amplifier 116 is
supplied to a narrowband first IF filter 118 arranged to
filter out signal components having frequencies outside
of a selected range.  For example, for television
applications, the narrowband first IF filter 118 ideally
20  filters out all undesired signal components having
frequencies outside of the frequency range of ±3 MHz from
the first IF center frequency.  This range depends on the
technology that is used and the quality (cost) of the
narrowband first IF filter 118.

The output of the narrowband first IF filter 118 is provided to one input of a second downconverting mixer 120 which also receives a local oscillator signal LO2 from a local oscillator. The second downconverting

5 mixer 120 mixes the signal from the narrowband first IF filter 118 with the local oscillator signal LO2 to produce a final output IF signal usually around 44 MHz.

The first IF amplifier 116 includes a transistor 122 having a gate 124 coupled to the output of

10 the wideband filter 114. The transistor 122 also has electrodes 126 and 128. These electrodes may be drain and source electrodes in the case where the transistor 122 is a field effect transistor as shown in Figure 3. However, the transistor 122 may be any other suitable

15 type of transistor or amplifier.

The electrode 126 of the first IF amplifier 116 is coupled to the input of the narrowband first IF filter 118. The electrode 126 is also coupled through a phase compensated divider 130 to an input 132 of an amplifier

20 134. The input 132, for example, may be a negative input of the amplifier 134. The phase compensated divider 130 attenuates the voltage at the electrode 126 to a level comparable to the voltage at the electrode 128 and compensates for the phase shift caused by the first IF

amplifier 116.  The phase compensated divider 130

includes a resistor 136, a capacitor 138, a DC decoupling

capacitor 140, and a resistor 142.  The resistor 136 and

the capacitor 138 are coupled in parallel, and the

5   parallel combination of the resistor 136 and the

capacitor 138 couples the electrode 126 through the DC

decoupling capacitor 140 to the input 132 of the

amplifier 134.  One end of the resistor 142 is coupled to

the junction between the resistor 136 and the DC

10  decoupling capacitor 140, and the other end of the

resistor 142 is coupled to ground.

The electrode 128 of the transistor 122 is

coupled through another DC decoupling capacitor 144 to an

input 146 of the amplifier 134, and is also coupled to

15  ground through a resistor 148 to provide resistive series

feedback and to close the DC circuit of the transistor

122 to ground.  The input 146, for example, may be a

positive input of the amplifier 134.  A resistor 152 and

a DC decoupling capacitor 154 are coupled in series

20  between the gate 124 and the electrode 126 of the

transistor 122 to provide parallel resistive feedback for

the first IF amplifier 116.

The output of amplifier 134 is coupled to a

detector 156, and the detector 156 is coupled through a

resistor 158 to the attenuator 104. The junction of the

resistor 158 and the attenuator 104 is coupled to ground

through a capacitor 160. The resistor 158, which is in

parallel with the attenuator control port input

5    resistance of the attenuator 104 and output resistance of

the detector 156, together with the capacitor 160

determine a time constant for the automatic gain control.

The detected signal at the output of the

detector 156 is used to control the attenuator 104 such

10   that the RF signal is attenuated in order to prevent

overloading of the mixers 112 and 120. The voltage on

the electrode 126 directly is the output voltage of the

first IF amplifier 116, and the voltage on the electrode

128 is proportional to the current in the first IF

15   amplifier 116. Therefore, the amplifier 134 receives two

signals, a first signal representing the voltage of the

attenuated signal (i.e., a properly scaled down voltage

from the voltage at the output of the first IF amplifier

116), and a second signal representing the current of the

20   attenuated signal. These first and second signals

provided by the first IF amplifier 116 complement each

other and together represent closely the incident power

at the output of the first IF amplifier 116. These first

and second signals are combined by the amplifier 134 and used to control the attenuator 104.

Variation in the input impedance of the narrowband first IF filter 118 is compensated because the

5 first and second signals provided by the first IF amplifier 116 complement each other as the impedance of the narrowband first IF filter varies. For example, as the input impedance Z of the narrowband first IF filter 118 increases, the signal on the electrode 126 increases

10 while the signal on the electrode 128 decreases, thereby stabilizing control of the attenuator 104.

The double conversion tuner embodiment 100, as depicted in Figure 3, has the advantage of providing a higher power level for the detector 156 compared with the

15 double conversion tuner 30 of Figure 2. Power sensing at a higher power level renders possibly the detector design easier and less costly. In addition, the AGC frequency spectrum to be amplified by the differential amplifier 134 and detected by the detector 156 is much narrower

20 than the AGC spectrum width associated with the double conversion tuner 30. The former AGC spectrum is a few tens of MHz (given by the RF filter bandwidth) centered around the first IF frequency while the latter is not converted to the first IF frequency. Also, the latter

AGC spectrum has to accommodate the entire tuning range

of the RF filter which is normally 50 to 800 MHz.  The

narrower the frequency spectrum to be amplified and

detected by the differential amplifier 134 and the

5    detector 156, the easier is the implementation of both.

Certain modifications of the present invention

have been discussed above.  Other modifications will

occur to those practicing in the art of the present

invention.  For example, a single conversion tuner 202 as

10   depicted in Figure 4 could be economically designed in

the conventional way with a varactor tuned single tuned

first RF filter 202, an AGC-able RF amplifier 204, a

varactor tuned double tuned second RF filter 206, an

active Gilbert cell mixer 208, LO, a wideband IF filter

15   210, a narrow band IF filter 212, and a SAW driver 214

coupled to a SAW 216.  The new parts inserted into the

otherwise standard single conversion tuner 200 would be

an IF preamp stage 218 in front of the narrow band IF

filter 212 to provide simultaneously the two taps for the

20   AGC voltage and current signals.  The two AGC signals are

coupled to the symmetric input terminals of an amplifier

220 driving a detector 222.

The wideband IF filter 210 may not be needed if

the mixer isolation from the RF to the IF port and from

the LO to the IF port is sufficiently large.  The RF and

AGC bandwidths are, for this design, basically identical.

The bandwidth of the narrow band IF filter 212, which is

centered around 44 MHz, should be such as to protect the

5  SAW driver 214 from strong adjacent channel interference.

The PIN attenuator used in the previous

embodiments is now replaced with the AGC-able amplifier

204, usually a dual gate MOSFET.

The bandwidth of the wideband filter 210, if it

10  has to be used, has to be somewhat wider than the RF

bandwidth resulting from the first and second RF filters

202 and 206 combined.  The signal driving the detector

222 is now band limited and centered around the IF

frequency 44 MHz, which means that all the additional

15  components become easy to design.

The embodiment as described in Figure 4 may

also be expanded into a symmetric configuration starting

with the active Gilbert cell mixer 208 up to the SAW

driver 214 if it has to be implemented within an

20  integrated circuit where most of the signal paths and

signal processing blocks are designed as symmetric ones.

Accordingly, the description of the present

invention is to be construed as illustrative only and is

for the purpose of teaching those skilled in the art the

best mode of carrying out the invention. The details may

be varied substantially without departing from the spirit

of the invention, and the exclusive use of all

modifications which are within the scope of the appended

5   claims is reserved.